Space Weather Technical Forecast

Issued on Saturday 5 October 2024 at 13:35 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Expected throughout, Chance of further R3. G1/G2 Expected, Chance G3 over UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured at GOES16 is at High levels, owing to multiple low-level M-class flares, peaking with an M1.6 event at 05/0844UTC. Penticton 10.7cm flux decreased a little to 291sfu from a peak in the current rotation of 312sfu on 03 October. The peak for the current cycle is 336sfu on 08 August.

There are ten sunspot regions on the disc. The largest regions AR3842, AR3844 and AR3848 broadly remained similar in appearance, although in the case of AR3842 some growth and consolidation was evident in the trailing spots of the group, as well as differential movement of the aforementioned spots. AR3844 demonstrated a tendency for the main larger spots to separate out longitudinally. All three regions maintain at least one delta spot, with AR3842 retaining multiple delta spots, indicating significant magnetic complexity. By comparison, the remaining regions are simpler and more stable, however, AR3849 in the southeast rotated into clearer view and contains a number of moderately sized intermediate spots between the main leading and trailing portions. AR3836 and AR3845 reached the far western disc and will soon rotate off the facing disc.

AR3842 and AR3848 have several small filaments strung through their constituent sunspots - something to monitor should any significant flares occur. Some instability was observed in filaments in the south-central and far southwest quadrant into the UTC evening of 04 Oct, although no Coronal Mass Ejections (CMEs) have been associated with these at the time of writing. Instead, the up to three CMEs seen heading southeast in Lasco C2/3 imagery through the UTC day are thought to be associated with a narrowly far-sided southwestern activity to no effect at Earth. A northeast-heading event on the same coronagraphs in the UTC evening was also thought far-sided.

No new Earth-directed CMEs were therefore in evidence.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1 was indicative of a near normal background regime. Speeds were largely steady, varying between 340-440km/s (Slow to Slightly Elevated). The solar wind density was Below Average throughout, but on a slight increasing trend late in the period. The IMF was broadly steady, varying between 6-9nT (Weak to

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Moderate) and an erratic north-south component ranging between +/-7nT. The phi angle was almost exclusively negative (towards the Sun).

Resultant Geomagnetic activity varied between Quiet and Unsettled levels (Kp1-3).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to Moderate levels (at diurnal peak), with a peak value of 160pfu at 04/1530 UTC. The associated 24-hour fluence was below the Active threshold, falling through the period to 4.25e6 observed at 04/2359UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be Moderate to High, with occasional M-flares expected and a chance of isolated X-class flares, most likely from AR3842, AR3844 and AR3848. Recurrence does not suggest any returning large regions over the eastern limb in the forecast period, and the major sunspot regions on the facing side are expected to be present throughout - the significant flare risk is therefore largely constant.

Solar Wind / Geomagnetic Activity: There are up to three CME arrivals in the period: firstly a possible glancing, but overdue blow from the X7.1 flare CME on Day 1 (05 Oct). Secondly and more assuredly, the arrival of a CME from the 03 Oct X9.0 flare should arrive either late Day 1 or early Day 2 (05 or 06 Oct). A third possible glancing CME impact, resulting from an M4.0 flare and filament eruption combination on 04 Oct has been added for late Day 3 (07 Oct).

A small, equatorial fast wind from a coronal hole may become geoeffective on Day 4 (08 Oct), but may be indistinguishable from the residual enhancements caused by the aforementioned CME arrivals that precede it. In either case, speeds for the high-speed stream are unlikely to exceed 500km/s.

G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) periods are Expected over the current UTC weekend, due to the potential arrivals of the X7.1 CME (possible) and then the X9.0 CME (expected). There may be a Chance of G3/Strong Geomagnetic Storm (Kp 7) conditions and even a Slight Chance of isolated G4 (Kp 8) intervals at peak. These larger-scale effects are perhaps most likely to straddle the intervening UTC night between Day 1-2 (05-06 Oct) and will rely on large, closely-spaced arrivals. Geomagnetic activity should then wane into the new UTC working week, with a further CMEs glance at best, while the fast wind component of the forecast is expected to be relatively minor in comparison.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is forecast to persist at Background, with a daily Chance of exceeding the S1/Minor Storm threshold should further significant flares occur.

High energy electron flux at GOES16 is expected to soon be further suppressed at GEO due to inbound CMEs, with a limited window for recovery before any fast wind from CH78/+ arrives

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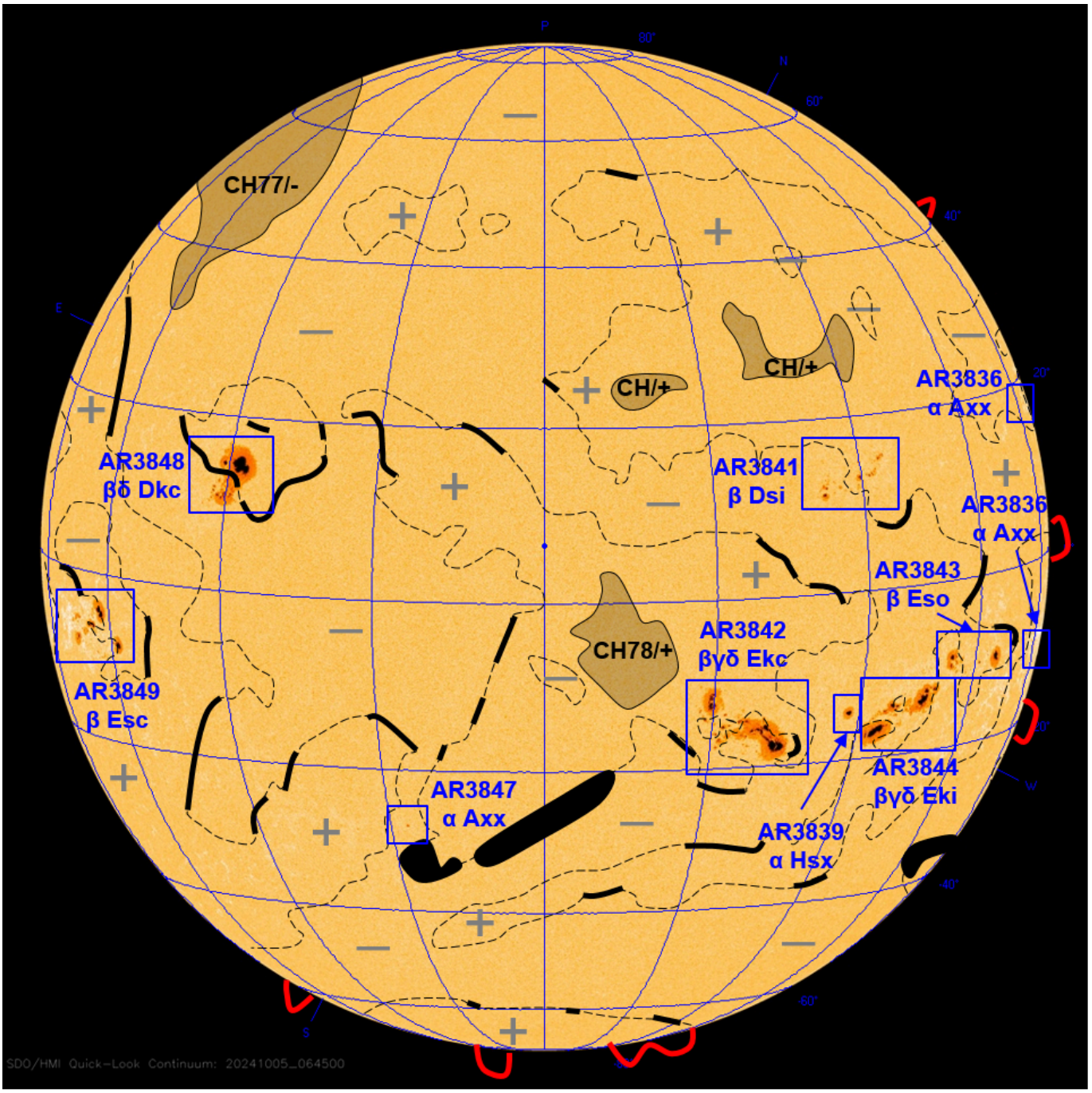
before midweek. There is a slightly rising Slight Chance of Active fluence on Day 4 (08 Oct), with lower than average confidence overall given the predominance of early CME activity.

Figure 1: Solar Synoptic Map valid 05/0700 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are up to three Earth-directed CMEs in the forecast period, along with the chance of some minor fast wind influence.

The CMEs comprise, firstly: a glancing, but overdue blow from the X7.1 flare CME (originating on 01 Oct) into Day 1 (05 Oct) with the bulk of the CME expected to pass to the south of Earth. Secondly - and perhaps more significantly - the arrival of a CME from the 03 Oct X9.0 flare, with a more direct hit expected to arrive - either late Day 1 or early Day 2 (05 or 06 Oct). A third CME is in evidence in coronagraph imagery following the M4.0 flare of AR3842 on 04 Oct, but overlaps with pre-existing ejecta from two filament eruptions in the southwest disc from a similar period. A glancing impact is possible according to MOSWOC Enlil later on Day 3 (07 Oct).

Small, equatorial CH78/+ may become geoeffective on Day 4 (08 Oct), but may be indistinguishable from the residual enhancements caused by the aforementioned CME arrivals that precede it. In either case, speeds for the high-speed stream are unlikely to exceed 500km/s.

ACE EPAM LEMS continue to show a steady rise, indicating an approaching CME, although it is not certain if this is in response to the 01 Oct, 03 Oct CMEs, or both. Enlil estimates of arrival times for all CMEs may be too fast, given that background solar wind speeds in Enlil are currently 100-150km/s above observed values at L1.

G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) periods are Expected over the current UTC weekend, due to the forecast arrivals of the X7.1 CME and then the X9.0 CME. Depending on how distinct these two events are and how much the first (lower confidence event) primes the magnetosphere, there may be a Chance of G3/Strong Geomagnetic Storm (Kp 7) conditions and even a Slight Chance of isolated G4 (Kp 8) intervals. These larger-scale effects are perhaps most likely to straddle the intervening UTC night between Day 1-2 (05-06 Oct) and will rely on large, closely-spaced arrivals. Geomagnetic activity should then wane into the new UTC working week, with a further CMEs glance at best, while the fast wind component of the forecast is expected to be relatively minor in comparison.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	80	60	20
Strong	G3	No	50	50	5	1
Severe	G4	No	20	20	1	1
Extreme	G5	No	5	5	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
02/0938	Partial	AR3842	SE	800	Imminent (from ACE EPAM LEMS evidence)	Low confidence based on estimates. +/- 12hrs arrival time.
03/1637	Full	AR3842	SW	882	05/1800 UTC	High confidence for being Earth directed, lower confidence arrival time.
04/1040	Partial	AR3842 + Filaments	SW	585	07/1800 UTC	Moderate confidence in arrival. Low confidence in timings.

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Figure 2: Latest MOSWOC Enlil output for 05/1800 UTC, estimated arrival time of 03 Oct CME. Enlil currently 100-150km/s too fast with solar winds, perhaps delaying arrival compared to indicated forecast.

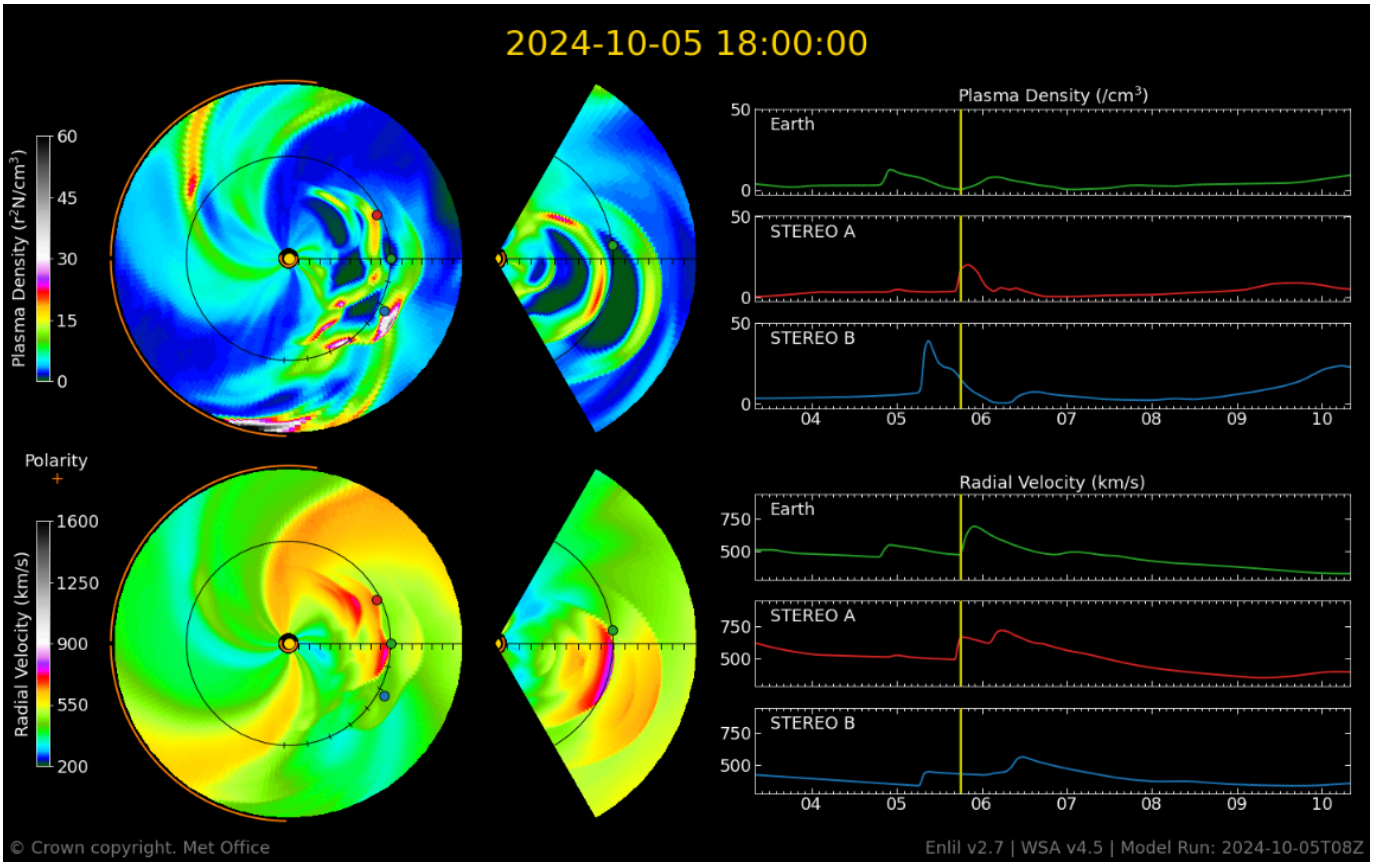
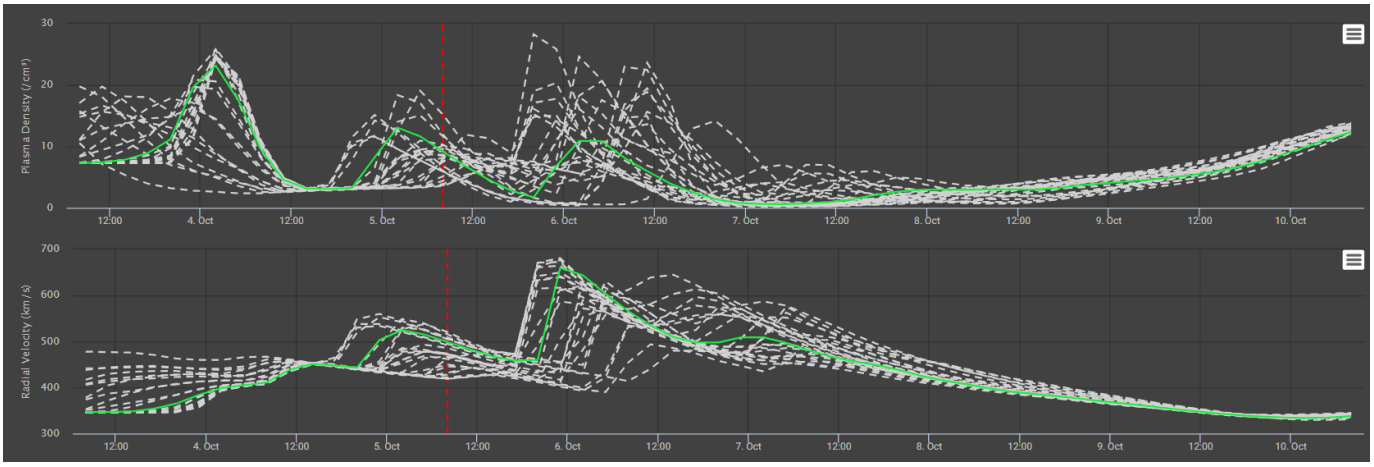


Figure 3: Latest MOSWOC Enlil Ensemble, indicating multiple potential CME arrivals during the forecast period.



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Radio Blackouts - X-Ray Flares

There are ten numbered sunspot regions on the disc.

The southwestern quadrant remains congested with large and complex regions at present, with AR3842 showing several Mt Wilson delta spots, a sheared appearance in its leader and growth and movement in its trailing spots. AR3844 - to its west - is also a large delta spot-containing group, with a spreading tendency seen between the leading and trailing regions. Thirdly, AR3843 further west was more open in character, again, with a spreading trend in the past 24 hours, although there is evidence that a very small delta spot may exist adjacent to the main trailer spot.

Of the three eastern hemisphere regions AR3848 and AR3849 are of particular note. The former retains a large spot that encompasses almost all of the region with mixed polarity evidenced within the broad penumbra of the group. AR3849 nearer the eastern limb has rotated into clearer view and contains a number of moderately sized intermediate spots between leader and trailing spots.

Far side helioseismographs and returning Carringtons due in the period suggest that there are no significant inbound complex regions in the coming four days. The disc should also retain both the major contributors to the daily risks at present - in the forms of AR3842, AR3844 and AR3848 and the forecast trend is therefore largely constant, only reducing slightly on Day 4 (08 Oct) due to the departure of AR3843 off the facing disc.

Solar activity is High. Solar activity is expected to be Moderate to High through the period, with a slight chance of rising to Very High, given the potential for isolated X10 or greater flares.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	90	90	90	85
Very Active	R3-R5 (X Class)	No	30	30	30	25

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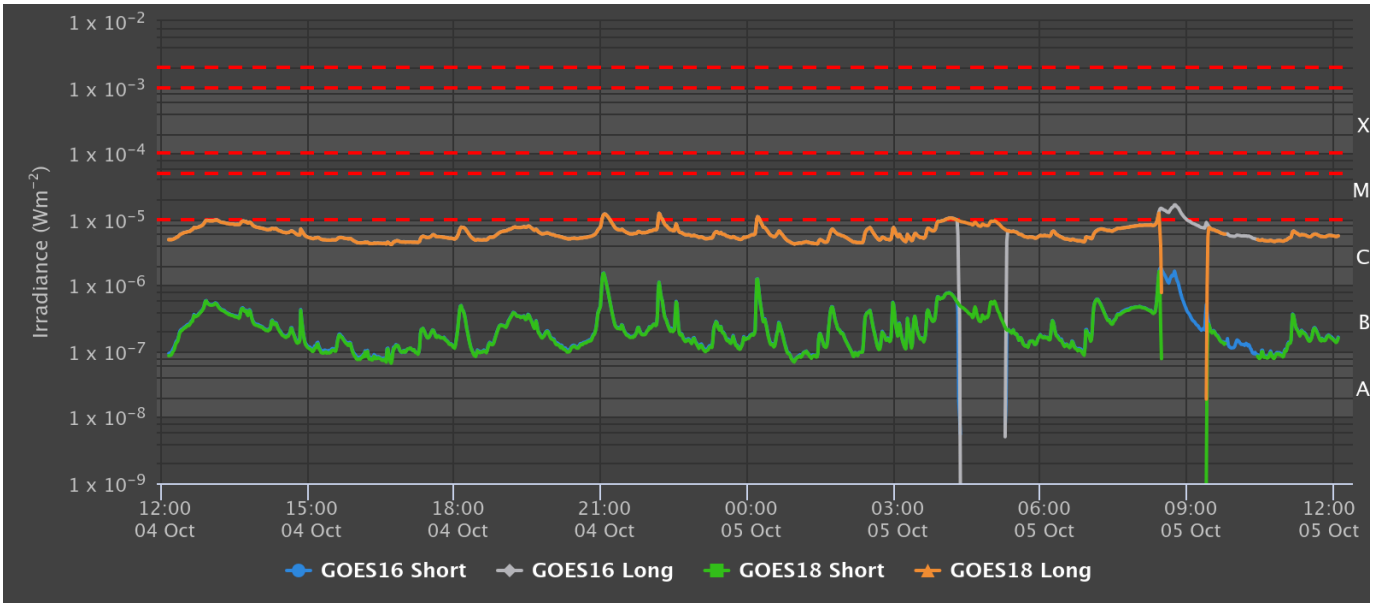
Figure 4: Latest GOES16/18 X-Ray flux, with five M-class flares observed during the past 24 hour period.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 has thus far failed to respond to any of the recent large flares, however this still becomes more likely with the sunspots' western advance. So, while modulated versus raw probabilities for the current disc, there remains a daily Chance of S1+, mainly from AR3842 or AR3844.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	25	25	25	25
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to Moderate levels. Forecast CMEs are likely to cause flux at GEO to reduce in the near-term, and the extent of any recovery before the onset of the sole fast wind the period on Day 4 (08 Oct) is also low confidence. Overall, there is perhaps a slight chance of this window being large enough to allow for a brief period of Active 24-hour integrated fluence late in the period - before again being attenuated. Any lasting recovery will probably therefore not come until later in the coming UTC working week.

MOSWOC REFM is not likely to offer a useful steer as to electron populations given the dominance of CMEs in the forecast.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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